Langdon (F. W.)

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THE ARACHNOID OF THE BRAIN.[1]

1. Its General Homology with the Serous Membranes of the Other Great Cavities. 2. The Communications of Its Cavity with the Subarachnoid Space.

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Modern works on human anatomy do not give, as a rule, an account of the cerebro-spinal arachnoid, which is, in the opinion of the writer, in harmony with its structure, topography, and relations as shown by dissection.

Some of the different views which have existed respecting the subject, as well as the present consensus of opinion of our commonly accepted authorities, are exhibited in the following historical notes:

According to Bichat,[2] "in the middle of the seventeenth century it began to be suspected that" . . . the arachnoid and pia . . . . "might possess a separate existence." "The Anatomical Society of Amsterdam assured themselves of the fact in 1665; Van Horne soon after demonstrated the arachnoides separately to his pupils."

Bichat himself[3] describes the arachnoid as a serous shut sac, conforming in all essential particulars with the serous membranes of the other cavities. This was apparently the generally accepted view up to the time of Kölliker, who wrote:[4] "It is generally stated that the inner surface of the dura mater is covered by an outer layer of the arachnoid; but nothing is found here excepting an epithelia composed of polygonal cells, and there is not a trace of a special membrane."

The same writer (page 238), speaking of the spinal membranes, says: "The inner surface of the dura mater is covered with a multiple layer of pavement epithelium cells, but has no other investment which could be regarded as a parietal lamina of the arachnoid." Again, Frey[5] says: "The arachnoid, which has also been numbered among these (the serous membranes), has no parietal layer." And, "The second membrane, the arachnoidea, was formerly described as forming a shut serous sac, but erroneously so; the parietal leaf being usually represented as fused together with the outer layer of the dura mater, since it could not be demonstrated separately."[6]

Without multiplying references unnecessarily, it is sufficient to state further that in the various editions of Gray's "Anatomy," previous to 1870, the arachnoid is described as a shut sac. Darling and Ranney, 1882, also teach this view; while Gray (after 1870), Holden, fifth edition, 1885, Leidy, 1889; Weisse, 1886, and other leading works in common use as text-books, speak of it as consisting of one layer only—the "visceral" layer.

It has occurred to the writer that this question of one or two layers was one which it was desirable to have settled, and if possible by macroscopic rather than micro scopic evidence. With this object in view a series of dissections were made as follows:

First dissection: Fœtus at term, stillborn.—The scalp being removed, a section of skull was made in the parietal region, removing the bone only. The following features were then easily demonstrated in successive order: 1. Periosteal layer of dura, traceable to its continuity with the sutural "ligament." 2. The dura proper (subserous connective tissue), forming the walls of sinuses and carrying the nutrient vessels for, 3, The parietal layer of arachnoid, a thin pellicle separable with the handle of scalpel. 4. Space between parietal and visceral layers of arachnoid, or the arachnoid cavity proper. 5. Visceral layer of arachnoid passing over sulci, etc. 6. Subarachnoid space. 7. The pia mater. 8. The convolutions.

Second dissection: Fœtus at term.—This was practically a repetition of the first, except as to region, the frontal bone being removed instead of the parietal.

Third dissection: Adult, negro, aged about thirty-five, brain and membranes normal.—The dura covering vertex and forming falx cerebri and tentorium was found to be inseparably united with the parietal arachnoid; at the base of the skull, however, and especially in the region of the sella turcica and orbital plates, the two membranes are quite freely separable with an ordinary scalpel, and the arachnoid could be stripped off in places. This separation also was more marked at the points of exit of the larger cranial nerves—*e.g.*, the optic. The following diagram (*A*) will show at a glance these points in the parietal region of the new born infant – the only change in adult life being fusion of the vertical parietal arachnoid with the subserous dura, a condition in every way similar to the conditions which exist in the pericardium. At the base of the skull, however, the separation is readily appreciable in the adult, as already stated.

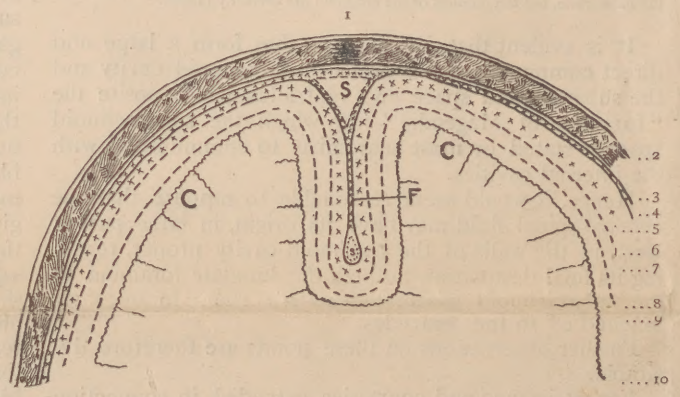

Diagram A. Vertical Transverse Section of Parietal Region to Show the Various Membranes and their Layers.—1, Sutural "ligament," continuous with external periosteum and periosteal layer of dura; 2, parietal bone; 3, periosteal layer of dura; 4, inner layer of dura, forming sinuses; 5, subserous connective tissue, between dura and parietal arachnoid; 6, parietal arachnoid; 7, arachnoid cavity; 8, visceral arachnoid; 9, subarachnoid space; 10, pia mater; S, superior longitudinal sinus; s, inferior longitudinal sinus; F, falx; C, convolutions.

Considering the nature of the sinuses—as simply dilated veins—and the fact that the inner dura is the necessary medium for vascular supply of the parietal arachnoid, it would seem in every point of view proper to consider the inner dura as homologous with the subserous connective tissues elsewhere.

The writer regrets that material and time have not permitted these observations to be carried to their logical conclusion, by actual sections of cranial nerve exits, to show the arachnoid reflections.

2. **The Communications between the Arachnoid Cavity and the Subarachnoid Space by Way of the "Lunulate Foramina."**—During the progress of the last dissection it was evident that there were two points at the base of the cranium where the arachnoid was deficient over a considerable area on either side of the medulla oblongata. These deficiencies present the form of bilateral foramina—one on each side—and are situated in the "bridge" of visceral arachnoid which stretches across from the cerebellar lobes to the under surface of the medulla. These foramina measure about half an inch in longitudinal diameter by one-fourth inch transversely, and are crossed by three or four fibrous bands, the attachment of which to the edges of the openings produces a mutiple crescentic appearance of their margins, which suggests the name adopted above. (See Diagram B.)

[1] Read before the Association of American Anatomists at the Annual Meeting, Boston, December 29, 1890.

[2] A Treatise on the Membranes in General, and on Different Membranes in Particular, by Xavier Bichat, etc. Paris, 1802. Translated by John G. Coffin, M.D. Boston, 1813, p. 163.

[3] Op. cit.

[4] Manual of Human Microscopic Anatomy, p. 237–238. London, 1860.

[5] Histology and Histo-chemistry of Man, p. 227. Appleton, 1875.

[6] Op. cit., p. 599.

As the body had been subjected to but little handling before the autopsy, and the brain was removed with special care, it does not seem likely that these openings were produced accidentally; the finished appearance of their edges and close correspondence with each other in all respects would also negative this supposition.

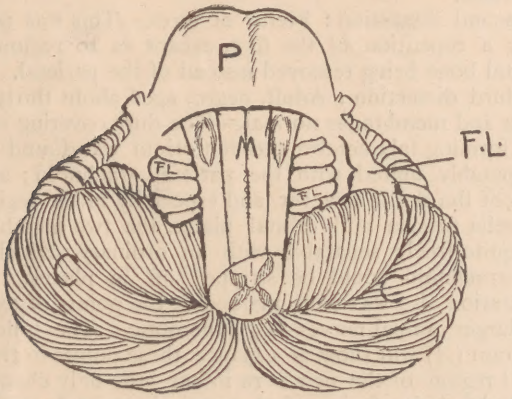

DIAGRAM B.—Lower or anterior surface of pons (P), medulla (M), and cerebellum (C), supposed to be covered by the visceral arachnoid, in which are seen the lunulate foramina (F.L.) in outline. NOTE.—The artist has failed to represent the membrane, but the outlines of the foramina are correctly placed.

It is evident that, if constant, they form a large and direct communication between the arachnoid cavity and the subarachnoid space and ventricles, just opposite the "foramen of Magendie"—by which the subarachnoid space is stated by most anatomists to communicate with the internal cavities.

Hence, it would seem reasonable to suppose that the cerebro-spinal fluid may have its origin, in large part at least, in the walls of the arachnoid cavity proper, reaching its final destination through the lunulate foramina to the subarachnoid space, thence *via* the "foramen of Magendie" to the ventricles.

Further observations on these points are therefore desirable.

For assistance and courtesies extended in connection with these dissections and observations, acknowledgments are due Dr. F. Kebler, pathologist, and Dr. George B. Twitchell, house-physician to the Cincinnati Hospital; also to Messrs. E. S. Newlin and J. G. Williams, students at Miami College.

To summarize these observations I would conclude:

1. The arachnoid membrane is a true shut sac, similar in structure and function to the serous membranes of the other great cavities. Its parietal layer is easily separable from the dura at the vertex in the fœtus and young infant, but practically inseparable in this region in the adult. At the base of the skull it is demonstrable as a separate membrane even in the adult. To assert that the parietal layer of arachnoid is absent, because its subepithelial connective tissue has fused at the vertex with the dura (connective tissue), is as incorrect as to describe the great omentum as one layer of peritoneum, because its original four layers have become matted and adherent.

2. The arachnoid cavity communicates freely with the subarachnoid space, by means of two foramina situated in the visceral arachnoid, one on either side of the medulla. For these I would propose the name "lunulate foramina," from their crescentic or lunulated edges, produced by the attachments of fibrous bands which cross the openings transversely. Subsequent observations, in two instances, confirm the presence of the "lunulate foramina." In one of these, the basilar process of the occipital and the sphenoid body were cut away from the base and the dura removed, so as to show the foramina *in situ;* thus excluding the possibility of their artificial production during the extraction of the brain.

CINCINNATI, December 16, 1890.

Typhus Fever and Cholera are prevalent to an unusual degree this year in Mecca.

THE PATHOLOGY OF THE CAISSON DISEASE.*

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(Concluded from page 150.)

III. THE THEORY OF CONGESTION WITH SEQUELÆ.—The theory of congestion was the first to be enunciated, and had as its basis anatomical facts, which were proved by the autopsies. The various modifications of it will be taken in order.

a. The Theory of Congestion and "Black Blood."—The upholders of this theory are Pol and Watelle,[86] Guerard,[49] and Limousin.[70] To Pol must be given the credit of showing that the danger of accident lay, not in the increased pressure, but in its too rapid diminution. His theory is, that the effects are produced by congestions of the brain and viscera and by "black blood." They base their theory on the result of two autopsies; in neither, however, was the spinal cord opened. In both, they found congestions of the brain, lungs, and the solid abdominal organs. These congestions they stated to be the immediate sequence of the compressed air forcing the blood mechanically from the compressible peripheral tissues into the deep-lying, practically incompressible organs. This central influx of blood gives rise to visceral congestions, which during the period of compression are innocuous; because, by reason of the increased pressure, the blood absorbs and holds in solution more than its normal quantity of oxygen. Therefore, although the blood-current in the affected organs is slower than normal, yet, on account of its superoxygenation it is able to give the tissues all the nourishment they need. Now, at the moment of removal of pressure what happens? They say that Rasori, Andral, and Dubois d'Amiens have shown that it is the stupefying action of the "black blood" that becomes pernicious, and that the period of removal of pressure is precisely that in which the blood loses its oxygen. Therefore, this "black blood," *i.e.*, the blood deprived of its oxygen, and the congestions which have not had time to disappear, manifest themselves in producing the divers accidents observed among the workmen.

Bauer[3] has a similar theory, except that he does not recognize the congestions.

The amount of oxygen absorbed by the blood during the compression is really very small, as has been proved by Bert, Chabaud,[17] and others. The following table will show this:

Atmospheres.	Oxygen.	Nitrogen.	Carbonic Acid.
1	20.0	2.2	40.0
2	20.9	3.0	40.7
3	21.6	3.9	37.2
5	22.7	6.0	35.7
7	23.0	7 0	35.5
10	23.4	9.4	36.6

This table shows that oxygen increases very slowly, carbonic acid decreases very slowly, and that nitrogen is the only gas that increases very much in the blood during the increased pressure. When we consider that man is rarely subjected to a pressure of more than four atmospheres, we see by the table that the change in amount of the gases dissolved in the blood at this pressure is really trifling, and not able to account for the lesions observed. Besides, the poisoning from the effete matters in the blood would be too slow in its action to cause the very prompt effects that are so often seen, and would be more apt to affect the cerebrum first, causing headache and drowsiness, than to attack the cord.

b. The Theory of Congestion followed by Evolution of Gas.—Boucquoi[11] advanced this theory. He says that the visceral congestions, under pressure, have different reactions for solids and fluids. The former are less and less compressed according to their depth; but that the

* Being the Merritt E. Cash Prize Essay of the New York State Medical Society, 1891.